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Effects of Organic Selenium and Zinc on the Aging Process of Laying Hens

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Abstract

The objective of the study was to determine whether supplementing the diets of post-molted hens with organic selenium (Se) (Sel-Plex®) and/or organic Zinc (Zn) (Bio-Plex®)[1] could improve laying hen performance. Prior to molting, 120-78 wk old laying hens were separated into four treatment groups of 30 hens per treatment and were subjected to molting. Molting was induced by reducing photoperiod from 16 h per day to 8 h, and the diet was changed from a standard layer diet (17% CP; 2830 ME/kg) to a straight crushed corn diet. When egg production was reduced to zero, the hens were fed a control diet, or a diet supplemented with 0.3 ppm Se/kg of feed; 20 ppm Zn/kg of feed, or a combination of Se and Zn. Lighting was restored gradually to post-molting period. Changes in daily egg production, egg weight, egg quality (albumen, yolk, and shell weights), feed utilization and hen mortality were recorded. Results indicated that mean egg production was significantly ($P<0.05$) greater and feed utilization was significantly ($P<0.05$) lower for hens fed diet supplement with the combined treatment of Se and Zn compared to the other diets. Single treatment of Zn significantly ($P<0.05$) lowered mortality and increased egg production, but significantly ($P<0.05$) reduced egg, albumen and shell weights.

Keywords: Post-molted hens; Organic selenium; Organic zinc; Layer diet; Egg production

Introduction

Laying hens are typically slaughtered when egg production levels fall below 55%, and in the United States, about 100 million hens fall into this category annually [1]. Before 2009, spent-hens were processed, and the meat from the hens was supplied to the National School Lunch Program [2]. However, this practice has recently come under intense public condemnation. Therefore, the productivity of older hens has become an increased concern to table-egg producers [3], and the layer industry is exploring nutritional strategies to extend the productive life of layers. These strategies include the utilization of high fiber diets [4], skip-a-day feeding [5], high calcium diets [6] and low energy feed [7]. Some of these strategies have raised animal welfare concerns because of the possibility of undesirable effects on the overall well-being of the laying hens [8]. The well-being of the birds during molting and their subsequent performance during post-molting have become a major concern [9], and some fast food industries will no longer purchase eggs produced by laying operations that use forced-molting programs [3].

Previous research has demonstrated that dietary selenium (Se) combined with zinc (Zn) can increase egg production and egg size in commercial laying hens [10]. Selenium is needed in the body as a core element of the enzyme glutathione peroxidase (GSH-Px) [11]. Zinc is also a trace mineral which is essential for animal and human health, and it is the principal component of the hormone insulin which regulates blood glucose level. The addition of Zn to basal diet of layers may significantly increase layer body weight without significantly effecting feed conversion or layer mortality [12]. Therefore, the objective of this study was to determine whether supplementing the diets of post-molted hens with organic selenium (Se) and/or organic zinc (Zn) could improve laying hen performance.

Materials and Methods

Experimental design

One hundred twenty 78 wk old White Leghorn hens were obtained from the laying house at the Poultry Research Center at Prairie View A&M University, Prairie View, Texas. Before the study, hens were fed a standard corn-soybean based layer ration consisting of 17% CP and 2830 ME/kg of feed and formulated to meet or exceed [13] specifications. All diets were iso-caloric and iso-nitrogenous and were provided ad libitum.

Induced molting

Molting was induced by altering photoperiod and ration of the hens. The standard ration fed previously was replaced with a straight crushed corn diet and provided ad *libitum*. Water was also made available ad *libitum*. Photoperiod was reduced to 8 h daylight per 24 h until egg production was reduced to zero. Before the start of the experiment the average daily egg production for the hens was 55% (Table 1). The hens were returned to lay 2 wks after the forced-molting process. Hens that died were replaced before beginning the experiment. Prior to molting the hens, the lighting period was 16 h per day, and the daily feed consumption was 165 g per hen.

Housing

Forced-molted hens were transferred to a naturally ventilated, open-sided layer house in a non-caged laying operation system. The house was cleaned, washed, and disinfected before stocking. Hens were separated into groups of 10 hens each with a stocking density of 0.81 m^2/hen on concrete floors covered with fresh pine wood shavings. Water was provided using automatic plastic hanging drinkers with one water

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Ingredients and content	Diet 1	Diet 2	Diet 3	Diet 4
	--------------------------- Percentage -------------------------			
Yellow Corn	55.93	55.93	55.93	55.93
Soybean Meal (44%CP)	22.10	22.10	22.10	22.10
Alfalfa Meal (17% CP)	5.00	5.00	5.00	5.00
Meat and Bone Meal	3.00	3.00	3.00	3.00
Animal and Vegetable Fat	3.00	3.00	3.00	3.00
Limestone	8.07	8.07	8.07	8.07
Di-calcium Phosphate	1.15	1.15	1.15	1.15
Iodine Salt	0.25	0.25	0.25	0.25
Vitamin Trace Mineral Premix[1]	1.50	1.50	1.50	1.50
Selenium (ppm)	0.00	0.30	0.00	0.30
Zinc (ppm)	0.00	0.00	20.00	20.00
Calculated Values				
Crude Protein (%)		17.00		
ME, kcal/kg		2830		
Phosphorus (available)		0.35		
Calcium		3.20		
Methionine		0.34		
Methionine and Cystine		0.62		
Lysine		0.76		

As-fed basis

Provided the following per kilogram of diet: vitamin A (as vitamin A acetate), 12,000 IU; cholecalciferol (as activated animal sterol), 3,000 IU; vitamin E (as ά-tocopheryl acetate), 20 IU; menadione sodium bisulfite, 2.0 mg; thiamine, 1.5 mg; riboflavin, 8.0 mg; niacin, 30.0 mg; pantothenic acid, 15.0 mg; pyridoxine, 4.0 mg; vitamin B_{12}, 15 μg; folic acid, 1.0 mg; biotin, 150 μg; cobalt, 0.2 mg; copper, 10 mg; iron, 80 mg; iodine 1.0 mg; manganese, 120 mg; butylated hydroxytoluene (BHT), 150 mg; zinc bacitracin, 20 mg.

Table 1: Composition of diets.

Treatments	Egg production		Feed utilization (g/g)	Mortality (%)
	before[1]	after[2]		
Control	55[a]	60[c]	4.51[a]	13.85[a]
Se	55[a]	62[c]	4.01[a]	11.25[a]
Zn	55[a]	73[b]	4.25[a]	0.00[b]
Se +Zn	55[a]	75[a]	3.15[b]	10.75[a]
SEM	0.96	7.59	0.57	6.13

a-cNumbers within columns with the same letter are not significantly different (P<0.05). n=30

SEM represents standard error of means.

[1]Mean egg production before forced-molted.

[2]Mean egg production after forced-molted.

Table 2: Single and combined effects of organic selenium (Se) and zinc (Zn) on egg production, feed utilization, and mortality of post-molted hens.

per pen, and feed was provided using one tube-type feeder per pen. A 2-tier, 10-hole nest box was placed in each pen for egg collection.

Experimental design, diets and data collection

Molted hens were placed on a standard layer diet supplemented with either organic Se or Zn (Alltech Biotech, Co, Lexington, KY). Diet 1 (control) was not supplemented with Se or Zn [8]; Diet 2 was supplemented with Se only (0.3 ppm/kg of feed); Diet 3 was supplemented with Zn only (20 ppm/kg of feed); and Diet 4 was supplemented with Se (0.3 ppm/kg) and Zn (20 ppm/kg) of feed. Hens were provided water with the diets ad libitum for 5 wks. The experimental design was 2 X 2 factorial arrangements of two levels of Se (0 and 0.3 ppm) and two levels of Zn (0 and 20 ppm).

Eggs laid by hens were collected daily and classified as nest-laid or

Treatments[1]	Egg weight	Yolk weight	Albumen weight	Shell weight
	------------------------------ g/g ------------------------------			
Control	67.61[a]	19.80[a]	40.20[a]	12.5[a]
Se	67.52[a]	20.50[a]	40.50[a]	12.5[a]
Zn	62.20[b]	19.10[a]	37.32[b]	10.0[b]
Se + Zn	67.85[a]	19.25[a]	40.61[a]	12.5[a]
SEM	10.38	0.63	1.55	5.76

[a-c]Numbers within columns with the same letter are not significantly different (P<0.05). n=30 SEM represents standard error of means.

Table 3: Single and combined effects of selenium and zinc on egg, yolk, and albumen weights of post-molted hens.

floor-laid and as cracked, broken, or soft-shelled. All layed eggs were used to evaluate daily hen-day production and mean egg weight. For each trial, 20 eggs were randomly selected from each treatment group, cracked open, and separated into yolk, albumen and shell. The yolk, albumen and shell weights were recorded. Feed was weighed at the beginning and end of the experiment to determine feed consumption. Mortality was recorded as it occurred. Each experimental treatment was replicated three times.

Statistical analysis

Data were collected on egg production, feed utilization, mortality, egg yolk, albumen and shell weights. Selenium and zinc were the main effects. All statistical analyses were done using ANOVA for a factorial arrangement of treatments. Means were compared using Duncan's Range Test. Main effects and interactions were considered significant at P<0.05.

Results and Discussion

Results indicate that organic Se and Zn, single and combined, have affected the performance of hens after forced molting. Hens fed Se plus Zn supplemented diets after 5 wks, had the highest egg production (75%), which was significantly higher (P<0.05) than (67.61%) the control. Feed utilization was also significantly (P<0.05) affected by Se plus Zn supplementation. Compared to the control (4.51 g/g), feed utilization improved significantly (P<0.05) (3.15 g/g) with the inclusion of Se plus Zn. Except for the single Zn-treatment (0.0%) mortality among the other treatments, including the control, was not significantly different (Table 2).

Table 3 shows that egg, albumen and shell weights (62.20, 37.32, 10.01 g/g, respectively) produced by hens fed Zn-treated diet, were significantly (P<0.05) lower than all the other groups, including the control. Egg, albumen and shell weights from hens on Se-supplemented feed were not significantly (P<0.05) different from the control. When Se was combined with Zn the egg weight, along with the albumen and shell weights were restored to the control levels. Yolk weights from the layers were not affected by the treatments.

Numerous researches have shown that trace minerals are now being used in poultry feed as prebiotics to enhance performance. Most research has examined the effects of supplementing feed with a single mineral, but little research had examined the effect of supplementing feed with 2 or more minerals. Selenium and zinc are trace minerals that play significant roles in the biochemistry of cellular functions in human and animals [14]. Deficiencies in these minerals can lead to immunological and structural problems of body cells. Selenium may play a critical role in the maintenance of optimal health; as it is required to maximize the activity of plasma glutathione peroxidase and other possible health benefit [14]. Suggested dietary levels of Se for poultry are 300 μg/d which are comparable to levels used in the present study. It has also been reported that although Se is an essential nutrient, excessive Se intake can be toxic in its organic form as sodium selenite [15]. To avoid Se toxicity, FDA has approved an organic form of Se, which is less toxic at higher dietary levels. Selenium and Zinc in the organic form also appeared to have higher bioavailability in laying hens performance compared to inorganic Se and Zn [11].

Traditionally, molting has been induced by implementing feed withdrawal ranging from 4 to 14 d accompanied by light restriction and/or the total removal of water for up to 3 d [16]. To reduce stress and induce molting, the hens in this study were subjected only to 7 d of low density feed, instead of feed and water withdrawal. Feeding crushed corn only to induce molting has not been reported to alter post-molting performance [8]. It appears that the method used in our study did not severely affect the physiological requirements of the hens. Furthermore, laying hens are prandial drinkers, and there is a close relationship that exists between feeding and drinking [17]. The free access to drinking water during the pre-molting stage, even though nutrient density was reduced, did not alter the post-molted performance of the hens.

During molt, reproductive tract of laying hens regresses and egg production ceases [4]. The improvement in egg production, egg, yolk, and albumen weights associated with the consumption of feed supplemented with Se and Zn would suggest that activity of these minerals has a synergistic effect on the integrity of the reproductive tract, and the improvement observed in performance could be due to the synergistic or additive effects of these two trace minerals.

As laying hens aged, their productive performance declines [16]. Older laying hens produce fewer and larger eggs, and poor eggshell quality. The results show that the combination of Se and Zn in the organic form as a dietary supplement increased egg production, produced larger eggs, lower feed utilization, and heavier eggshell weight in post-molted hens. The Se dietary supplement level was 0.3 ppm/kg, which did not appear to be toxic as it increased performance of post-molted hens. Also, during the aging process, laying hens increased the production of free oxygen radicals. Hence, older hens need high levels of antioxidant protection to protect cells and enhance tissue development. Older hens under induced forced-molting conditions require an effective antioxidant system which is dependent upon Se status of the cells and tissues. Also, as the hen aged, the need for energy increases. Zinc, which is a critical component of insulin synthesis, could have increased the bioavailability of energy for the transfer of glucose from the blood to the liver to be metabolized into energy. Eggshell quality is important as egg size affects the marketing of eggs. Poor eggshell quality leads to increased breakage and loss of revenues for the producer and the processor. Zinc supplement decreased eggshell weight which was elevated to the control level when it was combined with Se. By supplementing the diet of post-molted hens with organic Se and Zn the productive life of these hens could be extended.

Summary and Conclusion

Molting of older hens can be effectively implemented by reducing the nutritional density of the ration instead of withdrawing feed or water. The combination of Se and Zn as dietary feed supplements appears to have a positive synergistic or additive effect on the performance of post-molted laying hens. Commercial laying operations should consider supplementing feed with Se and Zn to extend the productive life of laying hens.

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[1]Sel-Plex and Bio-Plex are trade names for organic selenium and organic zinc produced and distributed by Alltech, Inc., Lexington, Kentucky, USA.

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